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Ecology and Management of Eurasian Watermilfoil (*Myriophyllum spicatum* L.)

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Figure 1. Eurasian watermilfoil stems and leaves. Photo by Alison Fox, University of Florida, available from Bugwood.org.

Abstract

Eurasian watermilfoil is a submersed aquatic forb with branching stems growing two to 21 feet (0.5 - 7 m) long and supporting whorls of featherlike leaves (see Figure 1). The pink inflorescence is a terminal spike two to eight inches long. Watermilfoil reproduces by seed and vegetative fragments, but colonization of new sites is mainly by vegetative fragments. It flourishes in eutrophic (low levels of dissolved oxygen, high levels of organic matter) lakes and waterways. Plants commonly grow in water three to 12 feet (0.5 - 3 m) deep and form tangled weed beds that can competitively displace submerged plant communities in two to three years. Dense beds reduce recreational qualities of water bodies, reduce water flow, create favorable habitat for mosquitoes, and clog industrial, agricultural, and drinking water supplies. Eurasian watermilfoil was first reported in Montana in Noxon Reservoir (Sanders County) in 2007. It is a Category 3 noxious weed. Water recreationalists are the predominant vector of long distance spread of Eurasian watermilfoil. However, waterfowl can also carry vegetative fragments from one lake to another.

Early detection and immediate action to contain and eradicate infestations are the most important management actions for Eurasian watermilfoil in Montana. If you find a new infestation, you

should save a specimen and report the infestation as soon as possible to your county Extension Agent or the Montana Department of Fish, Wildlife and Parks at http://fwp.mt.gov/fishing/fishingmontana/ans/default.html. It is highly susceptible to 2, 4-D. Repeated mechanical harvests may reduce stem densities. In reservoirs, water drawdowns during cold weather have reduced infestations. Larvae of the European moth *Acentria ephemerella*, and the native weevil *Euhrychiopsis lecontei*, are associated with plant declines.

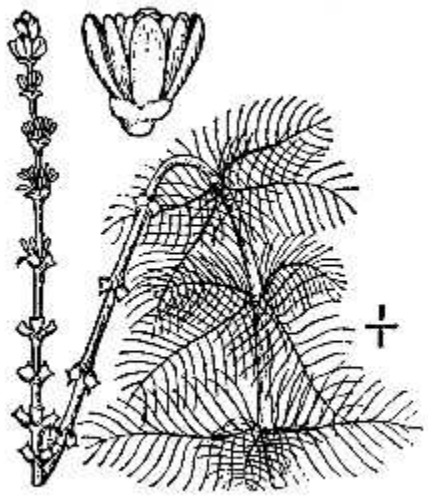

Figure 2. A sketch of the flower and leaf of Eurasian watermilfoil.

PLANT BIOLOGY

Identification

Eurasian watermilfoil is a submersed, aquatic perennial in the Haloragaceae family that roots to the bottom of water bodies. The roots are slender and fragile. Stems emerge from root crowns, are smooth and hairless (glabrous), and grow up to 21 feet (7 m) to the water surface, where they branch profusely. Stems have layers of specialized, partially lignified cells that enable the stem to self-fragment without mechanical disturbance. Stem fragments are capable of forming new plants. Leaves are whorled in groups of four at the stem nodes (see Figure 2), are 0.5 to 1.5 inches (1.5 to 4 cm) long, and have 14 to 24 pairs of threadlike divisions giving the leaf a feather-like appearance. Lower stem leaves continuously die and fall off. Pollen and seed flowers are separate on spikes that form at the ends of the stem branch. Spikes grow two to eight inches (5 - 20 cm) long and are often pink. They emerge from the water supported by the stem that is twice as wide as the lower portion of the stem. At the time of flowering, the spike is erect but bends at fruit set to be parallel to the water surface. Seed producing flowers lack sepals and petals but have a four-lobed pistil. Pollen producing flowers have four pink petals that drop off early in development, and eight stamens. Flowers are whorled in groups of four. The female flowers (seed producing) are lower on the spike than the male flowers (pollen producing), and the flowers in the middle are often bisexual. The fruits are globelike in shape, about 1/8 inch (2-3 mm) long with four long narrow grooves and four seeds.

In Montana there are two native species of watermilfoil that have similar leaf features as Eurasian watermilfoil: shortspike watermilfoil (*Myriophyllum sibiricum*), and whorl-leaf watermilfoil (*Myriophyllum verticillatum*). The easiest way to distinguish the invasive from the natives is by lifting a stem out of the water. The leaves of the invasive will relax and fall against the stem whereas the leaves of the native will remain rigid and spread from the stem. The natives can also be distinguished from Eurasian watermilfoil by the sparse stem branching near the water surface compared to the abundant branching of Eurasian watermilfoil, by the lack of conspicuous change in stem width below the inflorescence compared to the almost doubled stem width of Eurasian watermilfoil, and by the lack of the specialized layers of stem cells that facilitate stem fragmentation. Eurasian watermilfoil dies back to propagating root crown buds in the fall, whereas the natives form prominent cylindrical or cup-shaped perennating shoots (turions) attached to, or detached from the parent plant.

Life History

Although Eurasian watermilfoil produces seeds, most reproduction is asexual from stem fragments and root crown buds. Propagating root crowns typically break dormancy in the spring when water temperature and light intensity increase. Stem growth is limited by water depth, with growth occurring in water up to nine feet deep. However, Eurasian watermilfoil can grow in water up to 24 feet deep if it is very clear with high-light penetration. When stems reach the water surface, they branch abundantly forming a canopy near the water surface. The dense tangled mats can support frogs and wading birds. Lower branches and leaves constantly slough, adding nutrients to the water column throughout the growing season. The release of nitrogen and phosphorus can be rapid, and can be a significant source of internal nutrient loading to a lake. Plants flower mostly in late July to September. The female flowers ripen as the inflorescence spikes emerge from the water, well ahead of stamen development, favoring cross pollination. Fruits have a stony surface that prevents seed germination. Seed dormancy is prolonged (seven years), germination is erratic, and seedlings are considered rare in nature. Growth slows in the fall and a protective case over buds (hibernacula) may develop. Eurasian watermilfoil can maintain a large biomass throughout the winter which aids in rapid and early seasonal growth. It produces phenolic compounds that deter herbivores.

Stems fragment by natural wave action and by recreational activities such as boating. Differing from native milfoil species, Eurasian watermilfoil stems are adapted to self fragment by the development of specialized abscission stem cells, which typically occurs after flowering. One study found the growth of naturally produced fragments was better than artificially broken stems, and the naturally fragmented stems had higher total non-structural carbohydrate which enabled improved winter survival. Colonization is greatest during late summer in shallow (two feet) water on rich organic sediments. Mortality is greatest in deep water with calcareous, nutrient poor sediments during early autumn. In lakes in Wisconsin, South Carolina and Tennessee, annual biomass production varied from one to five tons per acre. Eurasian watermilfoil is adapted to use bicarbonate as a carbon source for photosynthesis, and although it is a C3 plant, it has structural adaptations similar to C4 plants that allow more efficient carbon utilization in the low carbon, submersed environment. Total non-structural carbohydrate in Eurasian watermilfoil may be highest (20%) in October and in plants under ice in the winter, and declines rapidly during spring flush to the lowest level (5%) in early summer.

Stem fragments allow for rapid colonization. For example, in New Jersey, researchers cleared a one by four meter area on the bottom of a heavily infested lake in mid-July. By early August, 15

rooted stems of Eurasian watermilfoil had established and by early September the number of stems had increased to 80. The following April, the cleared area was indistinguishable from the rest of the infestation, and there were no other plant species present.

Habitat

Eurasian watermilfoil can be found on every continent except Antarctica. It is native to Europe, Asia, and northern Africa. The details of its introduction to North America are unclear, but it may have been introduced near Maryland around 1940, possibly through the aquarium trade. It is problematic across the United States and many states have programs in place to prevent its establishment and spread. This exotic watermilfoil colonizes rivers, lakes, and other water bodies. It grows under a range of trophic conditions, but it is considered an indicator of eutrophic (low levels of dissolved oxygen, high levels of organic matter) conditions. It captures nutrients from both ambient water and sediments, but mostly from fine sediments containing 10-25% organic matter. Root anchoring may be impeded by sand, gravel, or flocculent (loose and fluffy) substrate textures. Growth is limited by light, preventing colonization of deep waters or water with high suspended particles. Optimum water depth for growth ranges from three to 13 feet (1 to 4 m), and a maximum depth for growth is 39 feet (12 m). Cold temperatures have little influence on growth except under reservoir drawdown conditions when plants are exposed to the air. Eurasian watermilfoil can use bicarbonate as a source of dissolved inorganic carbon, and high growth rates and dominance in hard, alkaline, high pH waters is common. It grows vigorously in salinities up to 10 ‰ (10 parts per thousand) and survives at 20 ‰ (20 parts per thousand) salinity (the concentration of brackish water). It can tolerate moving water, and water currents and wave action facilitate fragmentation.

Early detection is a priority for management of Eurasian watermilfoil in Montana, and predicting where it will colonize can focus surveys to susceptible water bodies. A Wisconsin study developed models to predict the likelihood of finding Eurasian watermilfoil based on its presence or absence in Wisconsin lakes. Variables associated with dissolved inorganic carbon were the most important factors predicting occurrence. These variables included alkalinity, bedrock, and forest cover. Lakes with a one percent increase in forest cover in their drainage were five to 50 times less likely to become infested than other lakes. Variables affecting Eurasian watermilfoil growth were better predictors of presence than variables indicating human activities. The presence of a public boat launch was the best human activity predictor, followed by the relative abundance of walleye and smallmouth bass. Lakes with a public boat launch were 21 to 28 times more likely to become infested than lakes without a boat launch.

Spread

Eurasian watermilfoil disperses primarily by stem fragments. Wind, waterfowl, water flow between water bodies, and human related activities are believed to be the main mechanisms of fragment dispersal. The most often cited vectors are motor boats and boat trailers.

Impacts

The dense weed beds formed by Eurasian watermilfoil have adverse effects on native aquatic vegetation that are important food sources for waterfowl and some mammals, and habitat for fish. The dense beds create habitat for disease carrying insects, including mosquitoes, and

parasites that cause swimmer's itch. The richness, diversity, and distribution of invertebrate species on lake bottoms are reduced where infestations occur. The function of water ecosystems are altered, including biomass turnover and nutrient cycling. Reduced dissolved oxygen and changes in water temperature are associated with infestations. Eurasian watermilfoil is a nuisance species to humans when it reduces open areas along lake shores, washes up on beaches, and curtails recreational activities. Populations reduce water flow thus interfering with industrial, agricultural, and municipal water systems. Irrigation ditches, canals, farm ponds, and irrigation equipment can be clogged by the weed. Management of Eurasian watermilfoil is difficult and expensive.

MANAGEMENT ALTERNATIVES

Prevention is the most important management option for Eurasian watermilfoil in Montana. Mapping, monitoring, early detection and eradication are critical to prevention. If a new infestation is found, save a specimen and report the infestation to your county Extension Agent or the Montana Department of Fish, Wildlife and Parks at http://fwp.mt.gov/fishing/fishingmontana/ans/default.html. Inspection and sanitation of recreational equipment will prevent spread. Any aquatic plant debris on boats, trailers, live-wells, boat bilges, and fishing equipment should be disposed of away from lakes, ponds and rivers. Establishing washing stations with sanitation instructions at water-based recreational sites is recommended.

Herbicide[1/]

Herbicidal control of Eurasian watermilfoil requires direct application of chemical to water. In Montana, applicators need a 308 Permit from the Montana Department of Environmental Quality before applying aquatic herbicides to water at (http://www.deq.state.mt.us/wqinfo/MPDES/permits/308/308AppFinal.pdf).

Eurasian watermilfoil is very sensitive to 2, 4-D. Only formulations for submerged aquatic weeds should be used (DMA*4IVM®) and all label requirements must be followed. Consult your local Extension Agent for more information on herbicidal control of Eurasian watermilfoil. The label rate maximum for 2, 4-D is 2.84 gallons/acre-foot of water and rate of application is dependent on water depth. Consult the herbicide label for rates at different water depths. Control is best when applied in early spring or early summer. Re-applications may be needed and should be applied before mid-August.

Mechanical Harvest

Repeated mechanical harvests have been successful in reducing stem densities of Eurasian watermilfoil. However, the risk of spread by stem fragments is high. Using fragment barriers around harvest operations and herbicidal control can prevent spread.

Water drawdown followed by exposure to freezing temperatures for 96 hours will kill plants. This method has reduced infestations, however re-infestation can be rapid.

[1/] Any mention of products in this publication does not constitute a recommendation by the NRCS. It is a violation of Federal law to use herbicides in a manner inconsistent with their labeling.

Biological Control

The watermilfoil moth (*Acentria ephemerella = Acentia nevea*), native to Europe, is associated with plant declines. The moth was first introduced into the United States in 1927 and it is established in eight eastern and Midwestern states. The larvae feed in and on the stems and leaves, and along with case-making, cause the leaves and stems to fall off the plant. Availability is currently limited. There is also a weevil native to North America, *Euhrychiopsis lecontei* that is associated with plant declines.

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